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AUTHOR Foch, Craig B.
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ABSTRACT

The National Preventive Dentistry Demonstration Project (NPDDP) delivers school-based preventive dental care to approximately 14,000 children in ten United States cities. The program, begun in 1976, is to be conducted over a six and one-half year period. The costing definitions and allocation rules to be used in the project are the principal subjects of this document. Information is presented on costs of labor, capital, materials, and overhead, donations of goods and services, participation rates, and phase one procedures. Plans are outlined for phases two and three of the NPDDP and include consideration of causes of cost variation at different sites, and planning for future operation of the program. Appended are tables providing information on sites, regimens, staffs, procedures, and forms. Also appended are costing definitions and allocation rules. (JD)

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A RAND NOTE

A COST ANALYSIS PLAN FOR THE NATIONAL PREVENTIVE DENTISTRY DEMONSTRATION PROGRAM

Craig B. Foch

June 1981

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Prepared For

The Robert Wood Johnson Foundation

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PREFACE

The National Preventive Dentistry Demonstration Program is being conducted to determine the costs and effects of various types and combinations of school-based preventive dental care procedures. This program is supported by two separate grants from the Robert Wood Johnson Foundation of Princeton, New Jersey. One of these grants is to the American Fund for Dental Health (AFDH), a national, nonprofit organization dedicated to the support of dental education, service, and research. The other grant is to The Rand Corporation, a non-profit research agency that conducts policy analysis studies for the public welfare and national security of the United States of America.

The initial concept for the Program was developed and presented to the Robert Wood Johnson Foundation by AFDH. Within the Program, AFDH is responsible for providing and supervising the preventive care, collecting the data, and conducting the annual dental examinations. Rand is responsible for monitoring these activities, developing the data collection forms and procedures, and conducting the data analyses. AFDH and Rand worked together in designing the Program, selecting the sites, and establishing the procedures for other areas of joint responsibility.

The program, begun in 1976, will be conducted over a six and one-half year period. The first year was devoted to planning, preparation, site selection, equipment development and procurement, and pilot testing. The sites were then activated on a phased schedule so that over the next four and one-half years each site's preventive care programs can run for a full four years. The Program's final year will

be spent in analyzing data and in reporting the results of these analyses. These data will include the results of dental examinations on approximately 25,000 children and information regarding the personnel, supplies, equipment, facilities, and time required to provide various kinds of school-based preventive dental care programs. The data base also includes background information about the children at each site who did and did not participate in the project.

This Note describes how the costs of the Program's school-based preventive dental care are to be defined and measured. For additional information, see Stephen P. Klein and Harry M. Bohannan, The First Year of Field Activities in the National Preventive Dentistry Demonstration Program (R-2536/1-RWJ), July 1979.

SUMMARY

The National Preventive Dentistry Demonstration Project (NPDDP) delivers school-based dental care to approximately 14,000 children in ten United States cities. Each of the children began receiving one or another of six different packages of procedures (called "regimens") during the 1977-78 school year and will continue its receipt for four years. Professional dental examinations establish each child's tooth decay status as of NPDDP start-up and annually thereafter.

The cost data generated by the NPDDP are to be analyzed in three phases. The objectives of phase one are (a) conversion of detailed records of personnel costs and time charges, supplier usage, and other expenditures to estimates of the Program's total cost at each site during each year of operation; and (b) division of those costs among the six regimens of preventive dental care. The costing definitions and allocation rules to be used in phase one are the principal subjects of this Note.

Phase two will be concerned with the causes of variation in costs among regimens, sites, and years. This information is necessary for phase three's construction of realistic cost estimates for various alternative hypothetical ongoing programs of preventive care--a process referred to here as scenario costing.

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I. INTRODUCTION

The National Preventive Dentistry Demonstration Program is currently providing a variety of school-based dental care services to approximately 14,000 elementary school children in ten United States cities. The dental care is preventive rather than restorative in nature, and all techniques being employed have been demonstrated to be both safe and effective in reducing cavities in a clinical setting. The purpose of the Demonstration Program is determination of the costs and effects of alternative regimens of care (various combinations of prevention measures) in a real-world setting. The ten Program sites were activated sequentially beginning in October 1977 and extending to April 1978; each site will be operated for a minimum of four years. Professional dental examinations at start-up and annually thereafter establish the baseline dental caries prevalence and subsequent oral health status of each child enrolled in the Program.[1]

Among several issues to be examined using data from the Program is the cost of school-based preventive care. Costs are to be analyzed for the Program itself and (by extrapolation) for potential ongoing programs in other settings.

In the context of cost estimation, the Program has several conceptually appealing features. First and foremost, it is set not in the laboratory, but in the real world. It is <u>not</u> a prototype for an ongoing program, where its data-collection machinery, annual

[1] For those not already familiar with the NPDDP, Appendix A provides background material on sites, regimens, staffs, procedures and forms.

examinations, and multiple regimens of care, for instance, would serve no essential purpose. But it faces, for the most part, market wages for personnel, market prices for equipment and supplies, mobile households, sometimes-recalcitrant teachers, and assorted other characteristics taken for granted in the real world, but carefully excluded from traditional clinical trials.[2]

Second, the Program faces a wide variety of local conditions--wage scales, sponsorship, racial and ethnic composition, degree of urbanization, and baseline incidence of tooth decay, to name a few--which may importantly influence the costs of care. Then again, some or all of these local factors may prove unimportant. Either way, the information is of clear value and can only be gotten in the sort of

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[2] The differences between traditional clinical trials and the real world are sometimes subtle, as may be illustrated by the following hypothetical example. A clinical trial and a real-world treatment program, let us suppose, use exactly the same complement of supplies purchased from the same vendor. The clinical trial receives its supplies through its sponsor, a dental research center. Because the trial is but one of many corsumers of supplies at the center, supply prices to be charged to the trial will reflect the volume discounts typically available to large-order customers and may or may not include a surcharge to cover a portion of the operating expenses of the center's purchasing department. The real-world treatment program, on the other hand, deals directly with the vendor. It also purchases supplies in bulk at discounted prices; but because it operates its own purchasing operation, it pays no surcharge.

If the trial pays no surcharge, or if the surcharge does not accurately reflect purchasing costs, then the trial's prices will obviously differ from those of the treatment program, but probably not by much. Less obviously, the volume discount available to the trial does not depend on its use of supplies, but rather on the center's purchases. There is no reason to believe *a priori* that the discounts available to the research center and to the treatment program would be equal. But even if they were, the cost results of the clinical trial would be misleading, because it would not (and could not) be reported how large a program must be to enjoy supply prices like those of the clinical trial. This information would accompany reports of the results of the (free-standing) real-world treatment program.

multi-site test offered by the Program.

Third, because the sites receive most of their supplies from a central purchasing agent (AFDH-Lexington) but are otherwise nearly self-sufficient, and because their experiences are being so thoroughly documented, it is possible to achieve nearly full cost accounting. Were the sites operating as adjuncts of larger nearby organizations (universities, say, or community dental clinics), informal undocumented transfers of resources between the sites and the larger entities become possible and therefore--by Murphy's Law--probable occurrences. Free-standing sites and ample documentation notwithstanding, hidden Program costs remain, principally centering on clinic space and transportation of clinic equipment. Hidden costs are always nettlesome, since the accuracy of cost imputation cannot be tested. But the minor role they play even here perhaps reveals what insidious contaminants they are.

The principal problem with the Program (from the point of view of cost analysis) is that some of its costs are not clearly attributable to one regimen of care or another, but are instead joint costs of two or more regimens. Most of the equipment for the mobile clinic, for example, is used in all three regimens involving one-on-one care. Site staff time devoted to general Program administrative functions provides a second, and more important, case of joint costs. When the site coordinator meets with school officials to plan clinic visits and training sessions for teachers, for example, several if not all regimens may benefit.

Joint costs are an inescapable consequence of providing the full menu of alternative regimens at each site with one local staff -- a

feature designed to facilitate treatment effects measurement. If each Program site dispensed but one regimen of care, there would be no joint costs to worry about; but one would also be less certain about what part of an observed difference between treatment groups at two sites to attribute to their differing regimens of care versus other differences between them.[3] If each site dispensed the full menu of care, but had a fully independent and fully equipped local staff for each regimen, then outcomes measurement would be as easy as it is now, and again there would be no joint costs to worry about. But total Program costs, holding the number of participating children constant, might be much higher than they now are.[4] Joint costs, in sum, are the result of tradeoffs in the Program's design, wherein some precision in cost estimation is sacrificed for greater precision in effectiveness measurement and for lower total Program costs.

In the estimation of Program costs of care, joint costs will simply be allocated among regimens according to traditional -- but essentially arbitrary -- rules of thumb. The arbitrary division of joint costs among regimens will somewhat distort the Program's estimates of the relative costs of alternative regimens of care, but averaging over all regimens the distortions will approximately cancel out. That is, costs

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[3] It should, however, be possible to make some division of the total observed difference by considering the no-treatment controls in the two sites, whose outcomes differ (by definition) only as a result of differences between the sites.

[4] What makes costs joint is that they are incurred as a result of the simultaneous pursuit of two or more goals. If those goals could be pursued independently of one another at lower total cost, then the jointness of costs was unnecessary and inefficient to begin with. Here it will be assumed that costs are joint for good reasons, from which it follows that total costs would otherwise be higher.

of care will be overestimated for some regimens and underestimated a similar amount for others.[5]

The problem of joint costs must be addressed with more sensitivity when extrapolating from the NPDDP to other, hypothetical ongoing programs of care. This is one of several reasons for division of the cost analysis into three distinct phases.

Phase one, detailed plans for which are the subject of Sec. II, will (a) determine what the total costs of operating (but not evaluating) the Program were at each site; (b) allocate each site's total costs among its several preventive care regimens; and (c) estimate regimen-specific participation rates which, together with regimen costs, will generate estimates of the per-student costs of care.

Phase two of the cost analysis will investigate the causes of variation in per-child costs of care across regimens, sites, and years. This information is necessary for phase three's construction of realistic cost estimates for various alternative hypothetical ongoing programs of preventive care -- a process referred to here as scenario costing. These two extensions of the cost analysis are discussed again in Sec. III.

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[5] If the Program would have cost much more to run with one regimen per site but with the same number of children per regimen as now, the division of joint costs may result in the underestimation of costs for all regimens of care.

II. PHASE ONE: PROGRAM COSTS OF CARE

There are three sources of costs associated with the Program at each site: (a) resource costs borne by the Program itself; (b) costs borne by others as a result of donations of goods or services, and (c) opportunities foregone by others as a result of Program activities. Some costs are directly attributable to particular regimens of care: e.g., treatment team salaries and fringes earned while dispensing one-on-one care in a school-based clinic. Other costs--e.g., staff salaries and fringes earned while attending staff meetings--go into the category of overhead and can only be indirectly linked to particular regimens by essentially arbitrary accounting rules. Together, these direct and indirect costs are defined to constitute regimen costs of care at each site. Combined with measures of Program participation, they yield regimen costs of care per student at each site.

The costs of labor, capital, and materials borne by the Program are discussed first. Donations of goods and services by local school districts and private parties, discussed second, are important conceptually because their dollar value is part of the real cost of care and pragmatically because future care programs might have to purchase what the Program receives gratis. Third come the opportunities foregone as a result of Program operations, which largely concern the use of classroom time and clinic space. Their importance stems not from their dollar value--which is in any event virtually impossible to determine--but rather from their influence on the Program's acceptability to school personnel, parents, and children.

These discussions of costs will in each case show how they are to be measured and how they are to be allocated among the regimens and overhead. Rules for dividing up overhead costs among the regimens are discussed fourth, and measures of Program participation (i.e., the number of students in each regimen at each site) come last. The discussion is nontechnical; readers interested in an algebraic presentation of the costing definitions and measurement techniques are referred to Appendix B.

II.1. LABOR COSTS

Personnel costs borne by the Program are reported monthly by each site in the Site Staff Expenditure Summary, and Site Staff Activity Logs show how each staff member divided his or her time between one-on-one treatment, classroom activities, community relations, management and administration, research, leave, slack, other project activities, and non-project activities. For those tasks performed at schools--principally one-on-one care and classroom activities--the Activity Logs also show which school was involved.

If all Program participants at a particular school were enrolled in the same regimen, identification of the school location of an activity would be tantamount to assignment of the activity to one or another regimen. An exact correspondence between schools and regimens, however, existed only at the beginning of the Program. The mixing of regimens that has occurred since then complicates but does not preclude the allocation of site staff time to regimens.

Time spent preparing for and monitoring classroom activities at multi-regimen schools can be allocated to regimens according to their aggregate representation at that school. If eighty percent of the Program participants at a school were enrolled in one regimen, and the other twenty percent were enrolled in some other regimen, for example, staff time spent on classroom activities there would also be split eighty percent/twenty percent between the two regimens.

Time spent preparing for and administering one-on-one care at multi-regimen schools, on the other hand, should not be allocated to regimens according to their aggregate representation because clinical time requirements per child vary from one regimen to another. Suppose, for example, that a treatment team is visiting a school with equal numbers of students in regimens one and two, and suppose further that regimen one's clinical procedures require twice as much time per child to complete as do regimen two's procedures. If staff time in the clinic is allocated on the basis of aggregate regimen representation at the school, equal shares will go to regimens one and two. But given their respective treatment time requirements, regimen one should be charged with two-thirds of the treatment team's time, while regimen two is charged with the remaining one-third.

Generalizing from the preceding example, the proper division (among regimens) of staff time spent in clinical activities at multi-regimen schools depends on the number of students in each regimen at that school and on the incremental treatment time requirement per child in each regimen. The incremental requirements can be approximated by average

time requirements,[1] using data from single-regimen schools: e.g., total staff time spent in clinics in regimen one schools divided by the total number of students treated in those schools gives the average time requirement per regimen-one student.

Activity Logs were completed for no more than three or four weeks of the first school year at nine of the ten Program sites.[2] The reason for this limited schedule of use of Activity Logs is that they were originally intended to serve only as periodic checks on Weekly Activity Schedules. The Weekly Activity Schedule also shows a what, when, and where for each staff member's activities, but it was supposed to be a planning document executed by the site coordinator. It was done prospectively at some sites and retrospectively at others. A comparison of Activity Schedules and Activity Logs at the end of the first school year, however, revealed that the former were wide of the mark more often than not; and it was decided, beginning with the second school year of

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[1] Total clinic staff time may be thought to be made up of fixed and variable components. The fixed components do not depend on the number or regimen of children treated that day; they are exemplified by (but not limited to) times spent opening up and closing down the clinic. The variable components are times spent actually treating children and will vary with both the number and the regimen of children treated. The variable time per child, averaged over all the children in a regimen, is the incremental treatment time needed for staff time allocation. It is different from the average clinic time per child, which includes both fixed and variable time components. The difference between average and incremental times per child might be important if the estimates formed the basis of costing (e.g., if they were multiplied by a wage rate to generate personnel cost estimates). Here the estimates serve only to allocate actual costs among regimens, so the slight difference between the two measures is of no real importance.

[2] Tallahassee, one of the last sites to start up, is a case apart. There, at the direction of the site director, Activity Logs were completed every week, but only those pertaining to the designated sample weeks were reported. Only later, when the existence of the other Logs was discovered, were they incorporated into a comprehensive record of school year one.

Program operations, to discontinue the Activity Schedule in favor of regular submission of Activity Logs.

If the Program's costs of care were to be estimated treatment year by treatment year,[3] the limited coverage afforded by Activity Logs during the first school year would have variable impact from one site to another. That is, for sites activated first, essentially all of the treatment year one activity data were lost; while for sites activated late in the school year, the loss of data was relatively minor. In order to eliminate this (unwanted) source of variance the Program's costs of care will be estimated on a school-year basis, beginning with school year two.

A school-year basis for cost estimation is desirable for two reasons other than first-year data problems. First, the staggered starting times for the ten sites are an artifact of the Program's demonstration status and may have resulted in different start-up costs than would have been incurred had the Program's and cooperating schools' operations been synchronized. Because such synchronization would be expected in an ongoing program, any effects on costs (positive or negative) resulting from the Program's staggered start are contaminants, and they should be removed. Second, as will be more fully explained below, the Program's use of supplies can only be determined on a school-year basis. Cost estimation on a treatment-year basis, therefore, would require resort to crude approximations based on

[3] A treatment year extends from one dental exam period to the next. It was thirteen months long the first time around, twelve months long thereafter, and may begin and end any time between September and March. A school year is arbitrarily defined to extend from August 1 to July 30.

averages over two different school years.

Salaries and other costs of employment of the site staffs constitute the bulk of labor costs attributable to the Program's operations. A second set of labor costs borne by the Program are primarily if not exclusively attributable to the Program's evaluation: e.g., payments to dentists conducting the annual examinations of Program participants at each site, and salaries of analysts. But a third group of Program labor costs resists such easy categorization, because the relevant personnel are engaged in both operational and evaluative tasks. Employees of AFDH and Rand, for example, make site visits throughout the year, not only assessing each site's adherence to treatment protocols and data collection conventions, but also providing instruction and otherwise solving problems. AFDH personnel also manage the purchase and distribution of supplies to the sites; and Rand, as part of its data collection efforts, provides services (e.g., preparation of rosters of participants) that would otherwise consume staff time at the site level. Formal incorporation of these "grey areas" in the measurement of costs would require retrospective data collection or the use of very rough estimates of personnel time allocations. It would also involve questions of joint costs of Program operations and evaluation, e.g., rosters of participants are necessary for both tasks, but need be produced only once. For reasons of practicality, therefore, estimation of these "grey area" costs is not presently planned; but it should be noted that their exclusion will negatively bias the resulting estimates.[4]

[4] A source of negative bias would be unequivocably undesirable if it were the only suspected error. Here, however, there are also rea-

II.2. CAPITAL COSTS

The second group of expenses borne by the Program at each site cover depreciation, interest, and repair costs of the durable equipment employed in the roving clinic (chairs, lights, power units, etc.). Each piece of equipment has a known initial purchase cost, an estimated useful lifetime, and a predicted scrap value (which might be zero) at the end of its life. The difference between purchase price and scrap value is the total depreciation expense for that type equipment; yearly depreciation is total depreciation divided by useful lifetime. For example, if a machine originally cost $1,000 and is expected to last 10 years, when it will fall into a (valueless) heap, yearly depreciation expense will be $100. Over the four years of Program operations, only $400 of the machine's original $1,000 value will have depreciated; the remaining $600 in machine value may be given away or wasted, but it should not be charged to the cost of care.

Interest costs are incurred even if no part of the initial cost is actually borrowed. They reflect the fact that the Program funds tied up in equipment purchases could have been invested elsewhere, earning returns all the while. For the first year at each site, interest is foregone on the full amount of the initial purchase cost; for the second, third, and fourth years interest is foregone on the purchase cost less accrued depreciation. The sum of depreciation, foregone interest and repair expenses (if any) during each year is the site's

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sons to believe that Program costs of care overestimate the costs of an ongoing program (e.g., overstaffing at some sites). It cannot be known if the several sources of error cancel one another, but the probability of offsetting errors is obviously higher when both positive and negative biases can be identified.

annual capital charge. The site's total annual capital charge will be allocated among the three regimens employing the mobile clinic in proportion to each regimen's share of total hours of clinic operation.

II.3. MATERIALS COSTS

The third group of costs paid by the Program are for materials consumed in clinical and classroom components of care and in overhead activities. Each site's purchases of care-related and non-care-related consumables are reported item by item for each school year in Treatment Expenditures Summaries and Non-Treatment Expenditures Summaries, respectively. Stocks on hand at the end of the school year at each site are reported item by item in Yearly Inventories. The total consumption of each item during a school year is equal to the stock on hand as of the end of the previous year (zero for the first year) plus that year's purchases, less stock on hand at year's end.

Non-care-related materials costs are charged to overhead. Allocation of each site's care-related materials costs among regimens, however, is somewhat complicated. Recall first that the several regimens are alternative combinations of a number of clinical and classroom procedures (see Table A-2). The procedures themselves remain the same from one regimen to another--only the combinations change. As it happens, care-related items are either consumed exclusively in one procedure (e.g., fluoride mouthrinse or plastic sealants), or at more or less the same rate whenever they are used (e.g., paper towels). In the former case, i.e., single-purpose items, each regimen employing the designated procedure bears a share of the total costs equal to its

number of students divided by the number of students in all regimens employing the procedure. Sealants, for example, are used in regimens one, two, and three at fluoridated sites. If their enrollments were equal, each of these regimens would be charged one-third of the total cost of sealants. At nonfluoridated sites, on the other hand, sealants appear only in regimens one and three. Again assuming equal enrollments, each would bear half the total cost. Allocation of the costs of items used in two procedures follows the same principle, but in the calculation of regimen shares, students in regimens employing both procedures are counted twice, while those in regimens using only one of them are only counted once.

II.4. DONATIONS OF GOODS AND SERVICES

Private parties contribute their labor services as volunteer teacher's aides, clerks, secretaries, messengers, and conductors of children between clinics and classrooms. Each site reports on its use of donated labor in the Monthly Volunteer Summary. This instrument is formatted much like the Site Staff Activity Log, showing for each volunteer the number of hours worked, the capacity in which the volunteer served, and the school location (which in turn identifies the regimen).

Volunteer labor, therefore, can be readily measured and allocated among regimens. It undoubtedly promotes the Program's operations and deserves recognition. There are, however, two powerful arguments against imputing a dollar value to this volunteer labor and factoring the imputation into the cost of care. First, there is the problem of

selecting an appropriate wage rate. Several candidates suggest themselves--the prevailing local rate for similar work, or the federal or local minimum rate--but they are all equally reasonable or unreasonable and equally lacking any substantive basis whatsoever. To impute a wage rate to volunteer labor is to say what that labor would have earned if gainfully employed, and how can that be known without a market test? A second problem with imputing a wage to volunteers is that they will not be utilized like paid employees. If a volunteer is available, it is in the interest of the site coordinator to find something for him or her to do. If today's task is of marginal or even zero value, the Program nevertheless benefits by making the volunteer feel useful, encouraged to volunteer again when there might be more important Program work for the volunteer to do.

Local school districts contribute some administrative services, office space for the local site staff, transportation of clinic equipment and supplies from school to school, and clinic space in each of the schools involved in one-on-one care. The physical dimensions of these contributions can be determined with relative ease, and they are each clearly linked either to overhead or to particular regimens. It is clear, too, that the Program costs of care would be higher without them--if indeed the Program could function at all. But attachment of costs to school district contributions nevertheless poses something of a dilemma.

If Program costs of care are to include only actual costs, then the relevant question is: Were local school district costs (i.e., budgets) higher as a result of contributions to Program operations? The answer

is most likely, No; school district contributions either employ resources that would otherwise be idle or they displace or defer one or more other, marginally-valued uses of district resources. The actual costs of the district's contributions, therefore, are either zero or some foregone opportunities.

But this is not a satisfactory resolution of the issue, because it results in understatement of the true costs of care. In an ongoing program involving such school district contributions, excess capacity might not always be available and district officials might not indefinitely countenance the loss of deferred educational opportunities. If no excess capacity exists and if pre-program educational objectives are maintained, local school district budgets must rise over time by an amount equal to the resource cost of the district contributions.

Because the costs of care in an ongoing program, to be discussed in the next section, would differ from the Program costs of care in other, perhaps even more important ways, however, it makes little sense to suspend the "actual cost" rule only with regard to district contributions. The more sensible path is to estimate what the district's resource costs would be in the long run, so they are available for "scenario costing" exercises, but formally to exclude them from the Program costs of care on the reasonable presumption that no costs were actually incurred by the district during the Program's run.

The amounts of time spent on Program business by various school district administrators and staff members, and the appropriate wage rate for each, can be determined from surveys of district officials. Neglecting indirect costs of administration (support services, materials

cost, etc.), the resource cost of district administrative contributions can be approximated by summing the products of surveyed times and wage rates of those involved.

Capital, maintenance, and utilities costs of office spaces and clinic spaces can be estimated from data on their respective sizes[5] (gathered by site staff) and prevailing local commercial space rents per square foot (easily obtainable from real estate firms in the community). Annual office space costs are equivalent to a full year's rental and are a part of overhead. Annual clinic space costs could range from a few months' rent, if the space were put to another, valued use when the mobile clinic is elsewhere, to a full year's rent, if the space is otherwise idle.[6] The cost of each clinic space is of course chargeable to the regimen using it.

Specification of the weight and volume of clinic equipment and supplies and the average length of school-to-school moves--obtained from clinic records and city maps--is sufficient information for price quotes from local moving companies. These price quotes are reasonable

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[5] Clinic spaces are sometimes larger than the minimum required. But if clinic operations preempt a space, its imputed cost is fully chargeable no matter what its size. This is but a particular instance of the widespread problem of "lumpy" resources: whether it be space, equipment capacity, or labor services, exactly the amount desired may simply not be available.

[6] It may seem somewhat odd that Program schools assigned to regimens involving one-on-one care should all have space in which to locate the mobile clinic. In point of fact, several sites originally sought to exclude particular schools from Program participation for lack of space, but all save Hayward later rescinded these prohibitions. One way or another, clinic spaces were always found; but some of them--e.g., hallways and teachers' lounges--imposed unwelcome burdens on school staff and students. This suggests that school districts do attach costs to the donated clinic spaces and that an ongoing program of preventive dental care would bear costs not borne by the Program.

approximations of the resource costs of equipment moves now supplied in most cases by local school districts or departments of health.[7] They will vary from site to site, because the sites have varying general price levels and varying average distances between schools. Annual moving costs, for each of those regimens involving one-on-one care, are equal to the product of the per-move estimated cost and the number of clinic visits for each regimen. For example, if two schools are assigned to one regimen, and the clinic visits each school twice during the year, the regimen would be charged for four equipment moves. Note that school size has a direct impact on the number of equipment moves and thus on the cost of care. In a district with a small number of large schools, the treatment team will make long visits and few moves. In another district with a large number of small schools (but the same total student population) the team will make short visits and more moves.

There is one final cost of the Program which, like those just preceding, is not met from Program budgets. Unlike the preceding, however, its conversion to pecuniary terms would be regarded by most observers as irrelevant, if not absurd. To wit, the Program's classroom

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[7] The current arrangements for clinic equipment moves, site by site, are as follows:

Chattanooga	. Department of Health van driven by AFDH employee
Billerica	. School District van and driver
New York	. Commercial movers
Minneapolis	. Department of Health van and driver
Wichita	. School District van and driver
Pierce County	. Rented van driven by site staff
Hayward	. School District van and driver; commercial movers
El Paso	. Department of Health van and driver
Monroe	. School District van and driver
Tallahassee	. School District van and driver

components consume classroom time, which is in fixed supply[8] and has other valued uses. The amount of time can be estimated from the Program's Teacher Questionnaire, but the opportunities foregone will differ in unknown ways from site to site and even class to class, depending on the ex ante curriculum and teachers' judgments (which may be implicit) concerning what to slight or eliminate outright.

II.5. OVERHEAD COSTS

At this point in the discussion of Program cost definition and measurement, all categories of costs--some borne by the Program, some not; some dollar-denominated, some not--can be imagined to have been allocated to one regimen or another or to overhead. The costs ascribed to overhead are now to be converted (conceptually) to "indirect costs of care" by means of essentially arbitrary accounting formulas. Their details will be brought out shortly, but it may be useful first to comment on the general nature of the problem at hand.

Most important, the existence of overhead costs is not evidence of waste or inefficiency. While inefficiency and waste can cause overhead costs to be higher than they would be otherwise, they can also cause direct costs (i.e., those fully allocable) to be higher than necessary. Overhead costs are legitimate, necessary expenses which differ from

[8] From the perspective of educational planners the length of the elementary school day is variable, and different school systems often have different hours. But these decisions probably reflect less about the desired content of the school day than they do about perceptions concerning teachers' and students' capabilities. Still, if the school day were lengthened to make room for classroom dental care, opportunities foregone would be non-school, and the longer day would result in higher school district resource costs (e.g., for higher teachers' salaries).

direct costs only in that they cannot be uniquely associated with one or another of multiple objectives. If the Program dispensed but one regimen of care per site, and were otherwise organizationally identical to what it is now, there would be no overhead cost problem. All local expenditures for one-on-one care, administration, community relations, or whatever, would be uniquely associated with that site's regimen and fully allocable to it.

The problem at hand, therefore, is not posed by the overhead costs, which are only creatures of organizational structure. The problem at hand, dictated by the requirements of cost analysis, is division of an intrinsically indivisible entity. Small wonder that the preferred solutions seem arbitrary; but they at least have the virtues of simplicity and widespread familiarity.

The first means of allocating overhead costs among the regimens is per capita: Overhead costs at each site are divided by the total number of children participating in the Program at that site, resulting in an indirect cost of care per student that is the same for all regimens. Since the regimens will have approximately the same participation rates, per capita allocation of overhead results in the regimens' bearing more or less equal shares of overhead costs.

The second overhead allocation technique is pro rata: Each regimen bears a share of total overhead equal to its share of total direct costs. Pro rata allocation results in much higher indirect costs per student for regimens employing one-on-one care (where the bulk of direct costs is incurred) than for classroom-only regimens. It is also conceptually equivalent to the widely-used overhead surcharge technique,

in which all direct costs are inflated by a constant percentage.

If the per capita allocation technique is used, there is also the problem of specifying whether overhead costs should be spread over all six of the Program's regimens or only over the five regimens involving preventive dental care.[9] The principal argument in favor of the latter course is that the overhead category includes many activities vital to the provision of school-based care but quite irrelevant to the maintenance of an experimental control group. Spreading the costs of these care-related activities across all six regimens therefore has the effect of overstating the costs of experimental control and understating the costs of care. Arguments in favor of allocating overhead among all six regimens are, first, that some overhead costs (e.g., recordkeeping) depend on the total number of participants at the site and, second, that there are almost certainly some unrecognized research costs at the site level. Allocation of a portion of overhead to the control group (whose costs are chargeable to research) would counteract the effects of such errors and omissions in the data. Thus, the arguments do not decisively favor either option. But a choice must be made--so overhead costs will be spread over all six regimens.

II.6. PARTICIPATION RATES

The sum of allocated overhead and direct costs for each regimen is defined to constitute that regimen's total cost per year. To convert these regimen total costs to regimen costs per student per year, it is

[9] With pro rata allocation the control group (regimen six) bears no share of overhead costs because it incurs no direct costs.

necessary to know the number of students participating in each regimen during each year of treatment. This sounds simple, but it is not.

The first difficulty is in determining what is meant by "participating." The easiest interpretation to implement would be yearly starting enrollments. But if sites and/or regimens differ in student attrition rates, those sites and/or regimens with the highest rates will have the lowest direct and total costs of care, other things equal. Dividing by starting enrollments would erroneously suggest that the sites and/or regimens with the highest student loss rates have the lowest per-student costs of care for the first year. High-loss sites and/or regimens would of course have lower starting enrollments for the second and third years, but the distortion of annual per-student costs persists. Conversely, the use of yearly ending enrollments --i.e., the number of students completing the treatment year--as the measure of participation would erroneously suggest that low-loss sites and/or regimens have lower costs per student.

The use of average enrollments would avoid these biases due to student attrition, because the low total costs of high-loss sites and/or regimens would be divided by low average enrollments and vice-versa. But there is another problem with enrollment-based measures of participation: Not everyone who is formally enrolled in the Program is actually receiving the care mandated by his or her regimen, and not everyone receiving Program care (and thus contributing to Program costs) is actually enrolled in the program. If enrollments are used to measure participation, non-receipt of care by some enrollees will cause per-student costs to appear smaller than they actually are, because some

enrollees appear in the denominator of costs per student, while adding nothing to its numerator; and the receipt of care by non-enrollees will cause costs per student to appear artificially high, since some non-enrollees are contributing to total costs but are not being counted as participants.

The principal reason for enrollees not receiving mandated care is physical absence from school during the period when care is being provided. For clinical components this period is the length of the mobile clinic's visit at a school. Classroom components, on the other hand, are delivered en masse: if a child is absent the day of the weekly mouthrinse, it is simply not received.

The receipt of care by non-enrollees is another story altogether. Clinical components of care are simply not administered to children not formally enrolled in the Program. Classroom components of care, on the other hand, are routinely given to all members of a class whose parents have consented. New students, for example, cannot be enrolled in the Program, but neither are they prohibited from joining in mouthrinsing, brushing, and tablet-taking.[10] Non-enrollees, therefore, raise the costs of classroom care but leave the costs of clinical care unaffected.

Since regimens consist of alternative combinations of classroom and clinical care, the effects of absent enrollees and participating non-enrollees will bias the comparison of costs per student across regimens. If these two factors differ among the sites, then comparisons of costs

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[10] And in some schools classroom care has been extended from the original cohorts--i.e., students in grades one, two and five at the beginning of treatment year one--to all grades in the participating schools.

from site to site will be biased also. Enrollments, therefore, are not good measures of classroom participation, at least for purposes of cost analysis, because they do not accurately reflect who is and is not consuming Program resources.

The obvious solution to this problem is to define Program participation by resource consumption: i.e., the number of children in each regimen is the number receiving that regimen's program of care. Children receiving less care than mandated by their regimen's protocol (due to absence from school, for instance) would in effect be counted as partial participants. This definition of participation poses no measurement problems for classroom procedures, because Classroom Censuses are conducted each spring and fall. During this Census a member of the local site staff visits each Program classroom and counts the number of children engaged that day in each phase of classroom care (i.e., fluoride mouthrinse, plaque removal, and fluoride tablets). The average of the two head counts during a given school year provides an estimate of annual classroom participation for that year in that school's regimen.[11]

On the clinical side, however, defining participation in terms of resource consumption raises a problem: there are no Program data collection instruments specifically designed to monitor the number of

[11] If the number of students is not constant, steadily rising, or steadily falling throughout the school year, but instead fluctuates in some irregular pattern, then the average of head counts made near the beginning and end of the school year will not accurately reflect the average number of students present. A large difference between the two head counts for a particular school/year combination would suggest such irregularity. If large differences between head counts are found, therefore, it may be necessary to design a different method of estimating classroom participation.

children receiving one-on-one care. Instead, these data must be approximated using clinical records kept for other purposes. The approximation procedure involves two steps. First, each site's daily records of clinical operations--i.e., the Daily Treatment Logs --are examined in order to identify strings of days when the clinic was operating at the same school. These strings can be less than a week in duration or as long as several weeks, depending on the regimen and the size of the school. The daily reports show the Program identification numbers of each and every participant who enters the clinic for treatment. Some of these participants remain seated only momentarily (e.g., those in sealants-only regimens with no sealable surfaces), and it might be argued that in some sense they are not actually consuming any Program resources. But regimens and sites will differ in the proportion of participants who appear at the clinic but have little or no work done on their teeth (for whatever reason). These differences will influence average effectiveness of care in those regimens and sites, and they should be allowed to influence the average costs of care also. This more powerful argument requires that all those listed on Daily Treatment Logs be counted as clinical participants, and that is what is planned.

In step two of the participation-approximation procedure, therefore, the number of distinct[12] enrollee identification numbers is

[12] Some participants will appear twice during a clinic's visit, and the requirement of distinct identification numbers is necessary to avoid double-counting. One reason for multiple appearances is interruption of a clinic session by the end of the school day. That is, a participant might appear at the end of one day and the beginning of the next. A second reason for multiple appearances is the need to check retention of previously applied sealants. That is, a participant might appear during the early part of the clinic's visit for a sealant appli-

determined for each string of days identified in step one. That number is one of possibly several estimates of participation at a particular school, corresponding to the one or more visits of the clinic during the year. Regimen participation at each site for the school year as a whole will be taken to be the average participation at each school, summed over all schools enrolled in that regimen.[13]

II.7 SUMMARY OF PHASE ONE PROCEDURES

For each job category-site-year combination, staff time will be allocated among the several regimens and overhead on the basis of Site Staff Activity Log school location codes. All time spent at single-regimen schools will be allocated to the school's regimen. Time spent in classroom activities at a multiple-regimen school will be allocated

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cation and again during the latter part for a sealant check. A third reason is that some sites do not treat all four quadrants of the mouth in a single visit.

This is an example of the effects of treatment plans on treatment costs. Some sites schedule participants for multiple appearances during the clinic's visit to a school. Other sites schedule multiple visits to the school to achieve the same purpose. The latter plan, of course, involves more equipment moves and more staff time spent setting up and closing down the clinic.

[13] Efforts are sometimes made to maintain the Program participation of children who transfer from one school to another at the same site. Regimen one children, for instance, can be maintained at a school offering regimen four (see Table A-2) if the clinic team makes a special visit to that school just to treat the transfers. These special visits, which will show up as apparent anomalies in the clinic participation estimation method discussed in the text, have much higher per-student costs of care than the clinic team's regular visits because the fixed costs of set-up, take-down, and transportation of clinic equipment must be spread over at most a relative handful of students. In order that the overall cost estimates not be biased by what is essentially an artifact of the Program's demonstration status, neither the costs of such visits nor the participants thus served will be included in totals. Dental examination data from these participants, however, will be included in the analysis of treatment effectiveness.

among the school's regimens in proportion to the numbers of children enrolled in each regimen at the school. Time spent in clinical activities at a multiple-regimen school will be allocated among the school's regimens in proportion to the products of average treatment times and numbers of children enrolled in each regimen at the school. The results of these staff time allocations will be reported in format "A."[14]

For each job category-site-year combination, staff time allocations to regimens and overhead will be divided by total hours worked to yield proportional shares. These proportional shares will be multiplied by total salaries and fringe benefits for the corresponding job category-site-year combination (from Site Staff Expenditure Summaries) yielding allocated personnel costs. These will be reported in format "A."

Supplies costs for each site and year will be calculated item by item, adding the value of starting inventory to the amount purchased during the year (from Treatment Expenditures Summaries and Non-Treatment Expenditures Summaries) and subtracting the value of inventory at year's end. The costs of non-treatment items will be assigned to overhead. The costs of treatment items used in a single procedure will be allocated among regimens employing the procedure in proportion to the numbers of children participating in each regimen. The costs of treatment items used in more than one procedure will be allocated among regimens employing any of the items' procedures in proportion to the products of numbers of children and numbers of procedures in each regimen.

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[14] Sample table formats appear at the end of this subsection.

Annualized clinic equipment costs for each site and year will be the sum of depreciation, foregone interest expense, and repair costs. These annual equipment costs will be allocated among regimens employing the clinic in proportion to the numbers of clinic hours assigned to each regimen. Equipment and supplies costs will be reported in format "A."

The direct cost of each regimen will be calculated for each site and year as the sum of personnel costs, equipment and supplies costs, and miscellaneous costs allocated to the regimen as described above. Direct costs will be reported in format "B."

Overhead costs will be calculated for each site and year as the sum of unallocated personnel costs, equipment and supplies costs and miscellaneous costs. Overhead costs will be allocated among regimens in proportion to (1) the number of participants in each regimen (per capita) and (2) the direct cost of each regimen (pro rata). Both sets of results will be reported in format "B."

Total costs for each regimen, for each site and year, will be calculated as (1) the sum of direct cost plus per-capita overhead cost, and as an alternative, (2) the sum of direct cost plus pro-rata overhead cost. Both sets of results will be reported in format "B."

Participation rates for each classroom-only regimen will be calculated for each site and year as the average of fall and spring Classroom Censuses for schools assigned to the regimen. (The results of Classroom Censuses at multiple-regimen schools will be allocated among regimens in proportion to regimen enrollments at the schools.) Participation rates for each regimen employing the clinic will be calculated for each site and year as the number of children treated

(from Daily Treatment Logs) during regularly-scheduled visits of the mobile clinic to schools assigned to the regimen. If the clinic visits a school more than once during the year, the average number treated will be used to calculate participation. When the clinic visits a multiple-regimen school, counts of children treated will be made for each regimen represented. Participation rates for the longitudinal control group for each site and year will be the number of control group children for whom annual examinations were completed that year. Participation rates will be reported in format "B."

Per-child costs will be calculated for each regimen-site-year combination by dividing the regimen's cost by its participation rate. Reported results will include (1) direct costs per child; (2) overhead costs per child, per capita allocation; (3) total costs per child, per capita overhead; (4) overhead costs per child, pro rata allocation; and (5) total costs per child, pro rata overhead. All results will be reported in format "B."

In order better to explain differences in per-child costs across regimens, sites, and years, and to prepare the way for scenario costing, staff time will be disaggregated by function (on the basis of Site Staff Activity Log activity codes) for each job category, site, and year. These functional breakouts will be reported as hours and as percents of total hours in format "C."

For the same reasons, volunteer time will be allocated among regimens and overhead (using the same procedures as for staff time) to be reported in format "A" and disaggregated by function, to be reported in format "C."

Clinical equipment moving costs will be estimated for each clinical regimen, site and year on the basis of the average distance between schools, commercial moving costs in each area, and the number of clinic visits each year. Results will be reported in format "D."

Table II-1: Format A

School Year:_____

Site	Water Supply	Regimen							TOTAL
		0*	1	2	3	4	5	6	
Chattanooga	Fluoridated								
New York	Fluoridated								
Minneapolis	Fluoridated								
Hayward	Fluoridated								
El Paso	Fluoridated								
Billerica	Non-fluoridated								
Wichita	Non-fluoridated								
Pierce County	Non-fluoridated								
Monroe	Non-fluoridated								
Tallahassee	Non-fluoridated								
Average of Fluoridated Sites									
Average of Non-fluoridated Sites									
Average of All Sites									

Staff Time, by Job Category (Hours)
- o Site Director
- o Site Coordinator
- o Treatment Team
- o Secretary/Clerk

Staff Salaries and Fringe Benefits, by Job Category (Dollars)
- o Site Director
- o Site Coordinator
- o Treatment Team
- o Secretary/Clerk
- o All Categories Combined

Equipment and Supplies Costs (Dollars)

Volunteer Time (Hours)

*Regimen "0" is overhead.

Table II-2: Format B

School Year:_____

Site	Water Supply	Regimen						TOTAL
		1	2	3	4	5	6	
Chattanooga	Fluoridated							
New York	Fluoridated							
Minneapolis	Fluoridated							
Hayward	Fluoridated							
El Paso	Fluoridated							
Billerica	Non-fluoridated							
Wichita	Non-fluoridated							
Pierce County	Non-fluoridated							
Monroe	Non-fluoridated							
Tallahassee	Non-fluoridated							
Average of Fluoridated Sites								
Average of Non-fluoridated Sites								
Average of All Sites								

Direct Costs (Dollars)
Overhead Costs, Per Capita Allocation (Dollars)
Total Costs, Per Capita Allocation of Overhead (Dollars)
Overhead Costs, Pro Rata Allocation (Dollars)
Total Costs, Pro Rata Allocation of Overhead (Dollars)
Participation Rates (Numbers of Children)
Direct Costs per Child (Dollars)
Overhead Costs per Child, Per Capita Allocation (Dollars)
Total Costs per Child, Per Capita Allocation of Overhead (Dollars)
Overhead Costs per Child, Pro Rata Allocation (Dollars)
Total Costs per Child, Pro Rata Allocation of Overhead (Dollars)

Table II-3: Format C

School Year:_____

Site	Water Supply	Clinical Treatment	Classroom / Assist Monitor	Administration	Community Relations	Down Time	Research	Other Program	Non-Program	Total
Chattanooga	Fluoridated									
New York	Fluoridated									
Minneapolis	Fluoridated									
Hayward	Fluoridated									
El Paso	Fluoridated									
Billerica	Non-Fluoridated									
Wichita	Non-Fluoridated									
Pierce County	Non-Fluoridated									
Monroe	Non-Fluoridated									
Tallahassee	Non-Fluoridated									
Average of Fluoridated Sites										
Average of Non-fluoridated Sites										
Average of All Sites										

Staff Time, by Job Category (Hours)
- o Site Director
- o Site Coordinator
- o Treatment Team
- o Secretary/Clerk

Staff Time, by Job Category (Percent of Total)
- o Site Director
- o Site Coordinator
- o Treatment Team
- o Secretary/Clerk

Volunteer Time (Hours)

Table II-4: Format D

Estimated Clinical Equipment Moving Costs

School Year:_____

Site	Water Supply	Avg. Distance Between Schools (mi.)	Est. Cost per Move (Dollars)	No. of Moves/Yr., by Regimen			Moving Cost/Yr., by Regimen		
				1	2	3	1	2	3
Chattanooga	Fluoridated								
New York	Fluoridated								
Minneapolis	Fluoridated								
Hayward	Fluoridated								
El Paso	Fluoridated								
Billerica	Non-fluoridated								
Wichita	Non-fluoridated								
Pierce County	Non-fluoridated								
Monroe	Non-fluoridated								
Tallahassee	Non-fluoridated								
Average of Fluoridated Sites									
Average of Non-fluoridated Sites									
Average of All Sites									

III. PLANS FOR PHASES TWO AND THREE

Costs of care provided by the NPDDP, allocated among regimes and expressed on a per-student basis (see Sec. II), are expected to say much about the relative costs of alternative combinations of decay-preventive procedures; and comparison of per-student costs across sites should suggest the possible range of costs of particular regimens of care under varying local conditions. But Program costs of care are not by themselves adequate for planning for ongoing programs of care, because (a) the Program's delivery system (i.e., one staff dispensing multiple regimens of care) is significantly different from most imaginable candidate ongoing programs,[1] and (b) the Program sites are not singly or as a group representative of national or even regional populations or conditions.

III.1 CAUSES OF VARIATION IN COSTS OF CARE

Phase two of the cost analysis will address the planning problem by exploiting the natural variation in per-student costs among regimens, sites, and years to examine the cost consequences of delivery systems, populations served, local labor markets, and other, unanticipated factors. Complete specification of the objectives of this work awaits the completion of phase one, but the following several examples should give the flavor of what is involved.

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[1] An example of a program that would closely approximate the NPDDP's delivery system is one that provided inexpensive prevention care (e.g., classroom fluoride mouthrinse) to all participants, while reserving intensive preventive care (e.g., prophy/gel and sealants) for "high caries risk" youngsters.

Economies/diseconomies of scale. Increases in the scale of operations (i.e., number of participants) may increase the efficiency with which care is provided (lowering the direct cost of care), but require more administration (increasing indirect costs of care). If the first effect dominates the second, per-student costs will decline with the size of the program. Conversely, if the change in indirect costs is larger than the change in direct costs, small programs would have lower per-student costs than large ones.

Indivisibilities. Program size may have no effect on the efficiency of care provision or administrative burdens, yet still influence costs per student. Suppose each hygienist on the staff of a clinical-care program could service 500 students each school year and that hygienists in this area will not accept offers of employment less than full-time. Per-student costs of care will then fall as program size approaches 500, ratchet upward with the hiring of a second hygienist as program size passes 500, fall again as program size approaches 1,000, and so on. The general problem is that while program size is continuously variable, staff (and equipment) may be hired only in discrete lumps the capacity of which may or may not be ideally suited to program size.

Learning Curves. In a multiyear program like the NPDDP, per-student costs may decline over time because the job is becoming easier (e.g., fewer sealants to apply after the first year) and/or because the staff is becoming more proficient at its tasks. Identification of the relative size of these effects is important. The first effect is an artifact of the NPDDP's demonstration status; in an ongoing program, new

additions to the population being served would be relatively small. The second effect -- often referred to as the learning curve phenomenon -- would be present in an ongoing program; but its importance would depend on the rate of staff turnover. If the typical staff member stays with the program for many years, proficiency will be maximized and per-student costs will be low. If the typical staff member leaves after but a year or two, correspondingly little benefit will derive from the learning curve, and per-student costs will be high.

III-2 SCENARIO COSTING

The foregoing examples of phase two cost analysis topics may be viewed as different applications of the general proposition that the costs of preventive dental care cannot be specified in the abstract and that they depend importantly on a host of details concerning what care is delivered to whom, how the program is organized and funded, and where it operates. Specification of these details constitutes a scenario -- a description of a hypothetical situation -- and estimation of the costs of care in that hypothetical situation is what is meant by scenario costing. This work constitutes phase three of the NPDDP cost analysis. Decisions regarding the content of these scenarios will determine what the reported costs of care are and how they will be used. These are matters important enough to require input from the Program's sponsor, from AFDH, and from others with interests in the future of preventive dentistry.

Numerous instruments document the delivery of care and the attendant consumption of staff time and materials. Site Staff Activity Logs and Special Activity Logs record hour by hour what each staff member is doing where, while engaged in routine and nonroutine Program activities, respectively. Site Staff Expenditure Summaries report each staff member's monthly salary, fringe benefits, travel allowances, and percent of time employed. Daily Treatment Logs are produced for each day the dental clinic is in operation, showing in which school the clinic is located and, for each child receiving care that day, the child's Program identification number, the procedures performed, and the identification number of the Program staff member who provided the treatment. One-on-One Care Summaries are also produced each clinic day, again showing in which school the clinic is located, how many of each procedure (i.e., prophy, gel, sealant, and/or sealant check) were performed, and the total hours in the clinic that day by dentists, hygienists, assistants, and clerks.

Treatment-Expenditure Summaries and Nontreatment Expenditure Summaries record each site's monthly purchases of equipment and supplies, identifying them item by item and detailing quantities and net costs for each. Yearly Inventories show the quantities of each category of equipment and supplies left on hand at the end of the school year.

Student-Participation Rosters are annual reports, for each school having classroom care components, of the number of days each participating student was present to receive the treatment. Classroom Censuses are semiannual one-day head-counts of students receiving classroom components.

APPENDIX A: SITES, REGIMENS, STAFFS, PROCEDURES, AND FORMS

The Program operates in the ten communities listed in Table A-1, chosen for their geographic and demographic diversity, and evenly divided between fluoridated and nonfluoridated water supplies.[1] The southeastern sites, Chattanooga and Tallahassee, both have substantial black populations and low costs of living; but Tallahassee is fairly prosperous and growing rapidly in population, while Chattanooga has the second lowest median family income of the ten sites and is declining in population. Program participants in Chattanooga, however, exhibit a median family income much closer to those of other sites, suggesting that they are not a representative sample of the larger community.[2] The two northeastern sites share high costs of living but are otherwise very different from one another. Billerica is a predominantly white, fast-growing, working-class community near Boston. The New York site, a school district in the borough of Manhattan, is somewhat poorer than is suggested by the table's city-wide measures (compare median family incomes of program participants) and is further distinguished by large enrollments of children of Hispanic and other[3] origin (27 and 28 percent, respectively).

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[1] Sites were designated as fluoridated (fluoride ion concentration of 0.8 part per million or more) or nonfluoridated (less than 0.2 part per million) on the basis of information contained in their applications for participation in the Project. The accuracy of this information is currently being tested.

[2] The Chattanooga site is actually "Hamilton County," and Program participants come primarily from suburban rather than city schools.

[3] Many of the children in the "Other" category are of Chinese origin; but the category also includes many other ethnicities. (One of the Program schools in New York sits in the shadow of the United Nations headquarters.)

Table A-1a

SELECTED MEASURES OF PROGRAM SITES (FLUORIDATED)

	Chattanooga Tennessee	New York New York[a]	Minneapolis, Minnesota	Hayward, California	El Paso, Texas
1975 Population	161,978	1,429,033	378,112	92,802	385,691
1975 Population Density (pop./sq.mi.)	1,413	62,953	6,813	2,392	2,418
1970-75 change in population (%)	-3.0	-7.2	-13.0	-0.3	19.7
1970 Percent White	64.4	71.4	93.7	94.2	96.9
1970 Percent Black	25.5	24.7	4.4	1.8	2.3
1974 Per Capita Income (dollars)	3,781	6,307	5,161	4,941	3,479
1970-74 Avg. Annual Rate of Change (%)	7.2	3.8	7.9	7.9	7.5
1969 Median Family Income (dollars)	7,112	8,976	9,958	11,095	7,962
1976 Consumer Price Index*	169.2[b]	176.3	170.9	168.0[c]	n.a.
1977 Urban Intermediate Budget,* Four-person Family (dollars)	15,483[b] 15,290[d]	19,972	17,813	18,519[c]	n.a.
Program participants:**					
Median Family Income (dollars)	15,876	9,839	18,687	16,707	14,501
Percent Anglo	90.0	34.0	94.0	63.0	41.0
Percent Black	9.0	11.0	4.0	8.0	3.0
Percent Hispanic	0.0	27.0	0.0	23.0	55.0
Percent Other	1.0	28.0	2.0	6.0	1.0

SOURCES: U.S. Bureau of the Census, *Statistical Abstract of the United States: 1978* (99th edition), Washington, D.C., 1978; U.S. Bureau of the Census, *City and County Data Book 1977* (A Statistical Abstract Supplement); U.S. Department of Labor, Bureau of Labor Statistics, *Handbook of Labor Statistics 1977.*

[a]Manhattan Borough. [b]Atlanta, GA [c]San Francisco-Oakland, CA [d]Nashville, TN

*Consumer Price Indices and Urban Intermediate Budgets are for the nearest of the twenty-odd metropolitan areas for which these series are available. Neither is reported for El Paso, TX, because the nearest city for which data are available (Dallas, TX) is over 600 miles away. Note that geographic area CPIs show relative rates of price *change*, not relative price *levels*.

**Preliminary estimates based on unedited data.

Table A-1b

SELECTED MEASURES OF PROGRAM SITES (NONFLUORIDATED)

	Billerica, Massachusetts	Wichita, Kansas	Pierce County, Washington	Monroe, Louisiana	Tallahassee, Florida
1975 Population	36,407	264,901	151,267	61,016	83,725
1975 Population Density (pop./sq.mi.)	1,379	2,800	3,165	2,676	3,136
1970-75 Change in Population (%)	15.0[e]	-4.2	-2.0	8.2	15.3
1970 Percent White	98.9[e]	89.5	91.0	61.7	74.0
1970 Percent Black	0.8[e]	9.7	6.8	38.2	25.1
1974 Per Captia Income (dollars)	3,959[a]	4,951	4,607	3,244	4,649
1970-74 Avg. Annual Rate of Change (%)	6.5[e]	8.4	7.5	6.6	9.3
1969 Median Family Income (dollars)	9,493[a]	9,519	9,539	6,690	9,078
1976 Consumer Price Index	174.5[b]	166.5[c]	164.5[d]	167.7[e]	169.2[g]
1977 Urban Intermediate Budget, Four-person Family (dollars)	20,609[b]	15,994	17,211[d]	15,283[f]	14,910[h]
Program Participants:**					
Median Family Income (dollars)	17,433	17,227	18,000	7,667	17,250
Percent Anglo	99.0	80.0	98.0	34.0	74.0
Percent Black	1.0	17.0	1.0	65.0	25.0
Percent Hispanic	0.0	2.0	0.0	0.5	0.0
Percent Other	0.0	1.0	1.0	0.5	1.0

SOURCES: U.S. Bureau of the Census, *Statistical Abstract of the United States: 1978* (99th edition), Washington, D.C., 1978; U.S. Bureau of the Census, *City and County Data Book 1977* (A Statistical Abstract Supplement); U.S. Department of Labor. Bureau of Labor Statistics, *Handbook of Labor Statistics 1977.*

[a]Lowell, MA [b]Boston, MA [c]Kansas City, MO [d]Seattle, WA [e]Dallas, TX [f]Baton Rouge, LA [g]Atlanta, GA [h]Orlando, FL

*Consumer Price Indices and Urban Intermediate Budgets are for the nearest of the twenty-odd metropolitan areas for which these series are available. Note that geographic area CPIs show relative rates of price *change*, not relative price *levels*.

**Preliminary estimates based on unedited data.

In the Midwest, Minneapolis and Wichita are predominantly white, prosperous, intermediate among the sites in cost of living, and declining in population (Minneapolis seriously so). The Wichita enrollment has twice the community representation of blacks, while 60 percent of Minneapolis participants are from parochial schools. Hayward and Pierce County, the West Coast representatives, are high-income, high cost-of-living areas declining slightly in population. Hayward is a working-class community near San Francisco-Oakland, with a large Spanish-surnamed Program enrollment. The Pierce County site is rural middle- to upper-middle class (measures in Table A-1 are for nearby Tacoma) with a 98 percent Anglo Program enrollment. And finally, there are the extremes of the southwestern cities: El Paso--fastest growing in population, 55 percent Hispanic enrollment, and the lowest incidence of decay of the ten sites. Monroe--lowest median family income of Program participants (only 41 percent of that of Minneapolis), 65 percent black Program enrollment, and the highest incidence of decay of the ten sites.

Each site has a local sponsor--dental schools in two cases; health departments in three; school districts in two; one university; one state dental association; and a dental research center--with responsibility for receiving and disbursing Program funds at the local level and for selection of local Program staff. Each local staff typically consists of (a) a dentist employed part time as site director with overall responsibility for the local operation, relations with the public and with other dentists in the community, and (where law requires) supervision of some aspects of the Program's clinical care; (b) a full-

time site coordinator in charge of day-to-day Program operations;[4] (c) one or two treatment teams of dental hygienists and dental assistants, whose principal responsibility is one-on-one dental care in school-based clinics, and (d) a secretary-clerk.

The sites were not activated simultaneously, but one by one, in a sequence extending over much of the 1977-78 school year. This somewhat complicates Program cost analysis, but was dictated by two overriding treatment effectiveness-related concerns. If the results of preventive dental care were to be compared across sites, it was necessary, first, to standardize as much as possible the measurement of Program participants' initial and subsequent states of oral health, and, second, to maintain a uniform interval between conclusion of each site's baseline examinations and its initiation of treatment. The only practical means of satisfying the first concern was to move examiners from site to site;[5] the second concern imposes the resultant sequential pattern of examinations on treatment start-up as well.

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[4] There is no easy way to describe the site coordinator's job adequately. The responsibilities include, but are not limited to, scheduling treatment team visits to schools, monitoring both clinical and classroom treatment components, ordering supplies, arranging transportation of equipment from school to school, escorting AFDH and Rand personnel on site visits, and completing both routine and special requests for data on Program operations.

[5] The Program employed 31 examiners in all during baseline examinations. The number of sites visited by individual examiners ranged from one to nine, with the greatest concentration (13) at three sites apiece. The concern over accuracy of the baseline examination process did not end here, but extended to explicit tests of examiner reliability. For a fuller discussion of these matters, see Stephen P. Klein and Harry M. Bohannan, The First Year of Field Activities in the National Preventive Dentistry Demonstration Program, The Rand Corporation, R-2536/1-RWJ, July 1979.

Baseline examinations were conducted on children in grades one through eight. Results from grades three, four, six, seven, and eight provide a cross-sectional control: these children have had no further involvement in the Program since the original baseline examinations. Children in grades one, two, and five were assigned to one or another of the six regimens of Table A-2. The objective of the assignment strategy was minimization of inter-regimen variation in ethnic composition and baseline amount of decay. Those assigned to regimens one through five will receive the indicated treatment and an annual reexamination for four years. Those in regimen six constitute a longitudinal control group: they will receive no treatment, but will be reexamined every year for four years.

The regimens consist of alternative combinations of clinical and classroom components (see Table A.3). For the former, treatment and supplies are transported from school to school to establish temporary dental clinics in space provided by the school district. Children are brought from their classrooms as they are scheduled for treatment and returned when finished, reducing the disruption of the school day as much as possible. The classroom components of care are group activities, usually directed by the teacher and made a part of the children's daily or weekly routine. Because children frequently move from one classroom to another, regimen integrity required that whole schools be assigned to single regimens.[6]

[6] The correspondence between schools and regimens was exact only at the beginning of the Program. In order to retain as many children as possible for the analysis of treatment effects, those who transferred from one participating school to another were maintained in their original regimens if it was practical to do so. This practice has produced multi-regimen schools at all sites, although the amount of mixing varies from site to site. In Billerica and Tallahassee, children in grade five in year one graduated to middle schools in year two, producing nothing but multiregimen schools for these cohort-site pairs.

Table A-2

TREATMENT REGIMENS

Regimen Number	Title	Fluoridated Sites		Nonfluoridated Sites	
		Clinic	Classroom	Clinic	Classroom
1	Comprehensive	Examination Prophy/Gel Sealants	Mouthrinse Plaque Control Education Prog. Diet Regulation	Examination Prophy/Gel Sealants	Mouthrinse Plaque Control Education Prog. Fluoride Tablets Diet Regulation
2	Modified Comprehensive	Examination Sealants	Mouthrinse Plaque Control Education Prog. Diet Regulation	Examination Prophy/Gel	Mouthrinse Plaque Control Education Prog. Fluoride Tablets Diet Regulation
3	Professional "One-on One" Care Only	Examination Prophy/Gel Sealants		Examination Prophy/Gel Sealants	
4	Classroom Activities Only	Examination	Mouthrinse Plaque Control Education Prog. Diet Regulation	Examination	Mouthrinse Plaque Control Education Prog. Fluoride Tablets Diet Regulation
5	Modified Classroom Activities	Examination	Plaque Control Education Prog. Diet Regulation	Examination	Plaque Control Education Prog. Diet Regulation
6	Longitudinal Comparison	Examination		Examination	

Table A-3

DESCRIPTION OF TREATMENT COMPONENTS

Treatment Component	Procedure and Rationale	Frequency of Treatment	Personnel Required
Fluoride paste prophylaxis (PROPHY)	An acidulated phosphate fluoride (APF) paste is used in a professional cleaning of the child's teeth. This 30-minute procedure provides topical fluoride protection and prepares tooth surfaces for the acidulated phosphate fluoride gel treatment.	Twice per year.	Auxiliary personnel consistent with minimum state dental practice legislation.
Acidulated phosphate fluoride gel (GEL)	Application of 1.23% fluoride ion gel in a styrofoam tray. This tray is kept in the mouth for a period of 4 minutes. Both arches are treated at same sitting. The gel treatment is applied immediately after the prophylaxis and provides topical protection to all tooth surfaces.	Twice per year in conjunction with the prophylaxis.	Auxiliary personnel consistent with minimum state dental practice legislation.
Sealant	A sealant is a plastic-like resin that adheres to the teeth. This transparent coating (Delton) is applied in about 30 minutes to the occlusal surfaces of posterior teeth of both arches that are not already carious or filled. The seal provides topical protection to the surfaces treated.	After initial application, seals are checked every 3 months.* If a seal is lost, it is reapplied a maximum of 3 times.	Dental or auxiliary personnel consistent with minimum state dental practice legislation.
Systemic fluoride tablet (FLUORIDE TABLETS)	One mg of fluoride by 2.2 mg of neutral sodium fluoride tablet is chewed and swished for one minute and then swallowed. This procedure provides both systemic and topical fluoride protection.	One tablet per day during the school year.	Classroom teacher or aide.
Fluoride mouthrinse	A 0.2% neutral sodium fluoride solution is served to the child in a paper cup. The child swishes the solution between the teeth for 60 seconds and then expectorates into the cup. The child does not swallow the solution. This procedure provides topical fluoride protection.	Once per week for each week of the school year.	The classroom teacher or aide supervises the administration of the mouthrinse.
Plaque control	Children in grades 1, 2, and 3 cohorts brush in school without a dentifrice. The grade 3 cohort also uses dental floss. These procedures are designed to remove plaque (and thereby the bacteria) that causes tooth decay and gingivitis. A supply of ADA-approved fluoride dentifrice is provided for home use.	Twice weekly supervised exercises in the classroom. Disclosing solution is used at least once per month.	Dental auxiliary demonstrates appropriate procedures and periodically visits classrooms to ensure they are being followed. Teacher or aide provides routine supervision of classroom activities.
Education program	This program consists of a series of 10 units (about 50 minutes each) that were selected for the program from existing materials designed to promote appropriate oral hygiene and health. Different materials were prepared for each grade level.	Individual teacher decision as to whether taught as a unit or spread over school year.	Classroom teacher after orientation by program education coordinator.
Diet regulation	This component consists of efforts to reduce the frequency of refined carbohydrates in school food programs and to encourage the elimination of cariogenic snacks.	Every school day throughout the year.	Education coordinator working with school dietician, administrators, parents, and children.

*After the first treatment year, the interval between sealant checks was increased to six months.

APPENDIX B: COSTING DEFINITIONS AND ALLOCATION RULES

The definitions and procedures planned for Program costs of care, discussed in nontechnical terms in Sec. II above, are repeated here in formal algebraic notation. The order of presentation is: (1) participation rates; (2) labor costs; (3) supplies costs; (4) capital costs; (5) direct costs; (6) overhead costs; (7) total (direct and indirect) costs; and (8) costs per child. Because the definitions and procedures--with the single important exception of those pertaining to capital costs--are the same for all sites and school years, the algebra omits all mention of them. The following, therefore, pertains to a particular (but unspecified) site and year; it will be replicated, with different data, for each site-year combination.

B.1. Participation Rates

Counts of participants serve two purposes in Program cost analysis. First, counts by regimen are the denominators of regimen costs per child. Second, counts by regimen within each school are used to allocate staff time among the possibly several regimens represented there. Different estimation techniques are planned for classroom and clinical participation rates. The clinical technique is discussed first.

Clinical Participation. For each day during which the mobile clinic is operating, there is a *Daily Treatment Log* identifying the school in which the clinic is located and the children admitted for treatment. Assuming that the staff endeavor to treat all clinical-regimen children at a school during an approximately continuous visit, *Daily Treatment Logs* will form same-school, consecutive-day strings.*

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*If the assumption is incorrect, a different participation-estimation technique will be required. The form this alternate technique will take depends on how the site staff actually operates the clinic. The validity of the "everybody treated" assumption will be tested by comparing a school's clinical participation rate with the number of children enrolled in clinical regimen and assigned to the school. Small differences between participation rates and enrollments are expected; only large differences between the two would signal trouble with the participation-estimation procedure.

The regimen of each child appearing during the clinic's visit can be determined from the master list of Program enrollees. Let the number of children from regimen r appearing during the clinic's visit to school s--or the average number, if the clinic makes more than one visit during the year--be N1[s,r]. Holding r constant and summing over schools produces clinical participation rates N1[r]:

$$N1[r] = \sum_{s} N1[s,r] \qquad (1)$$

Classroom Participation. Each classroom in which Program care is being provided is visited near the beginning and end of the school year by a site staff member, for the purpose of counting the number of children participating in classroom procedures that day. Aggregated to the school level, these semiannual headcounts are reported as *Classroom Censuses*. Let the average of the fall and spring counts for school s be N2[s].

Master lists of Program enrollees show the regimen assignment (which is constant) and the current school assignment of each enrolled child. Let the number of enrolled children from regimen r currently assigned to school s be E[r,s] and let the number of enrolled children from all regimens combined assigned to school s be E[s]. The planned estimate of classroom participation in regimen r at school s, N2[r,s], may then be written

$$N2[r,s] = \frac{E[r,s]}{E[s]} \cdot N2[s] \qquad (2)$$

The classroom participation rate for regimen r, N2[r], is the sum of the N2[r,s] over all schools at the site:

$$N2[r] = \sum_{s} N2[r,s] \qquad (3)$$

B.2. Labor Costs

Activity Logs are completed weekly by each site staff member, identifying by codes the site, the staff member, and--for each half-hour increment of the workweek--an activity and its location. Thus,

Activity Log data for all staff members and all weeks in the school year may be thought of as a series of code triples [i,a,s], where i identifies the staff member, a is the activity, and s is its location. Let H[i,a,s] be the total number of times the [i,a,s] triple is observed.

The activity code categories are: annual dental examinations; one-on-one treatment, classroom procedures, community relations, management and administration, research, vacation and sick leave, slack time, and non-Program activities. Location codes refer either to one of the participating schools or to a catchall non-school category. This wealth of detail should prove valuable in efforts to discover the causes of inter-site and inter-regimen differences in costs of care. For the purpose of allocating staff time among regimens, however, activities and their locations reduce to the four groups of Fig. 1.

<table>
<tr><th rowspan="2">Activities</th><th colspan="2">Location</th></tr>
<tr><th>School</th><th>Non-School</th></tr>
<tr><td>o Annual Exams
o Research
o Non-Program</td><td colspan="2">Non-Operational</td></tr>
<tr><td rowspan="2">All Other Activities</td><td>Clinic</td><td rowspan="2">Overhead</td></tr>
<tr><td>Classroom</td></tr>
</table>

Fig. 1

Non-Operational Activities. The "Non-Operational" group consists of those activities--annual examinations, research, and non-Program--which do not support Program operations. Some of these activities will take place at participating schools, others will not. All staff costs traceable to this "Non-Operational" group will be subtracted from totals before allocation of costs to regimens.

Clinic Activities. The "Clinic" group includes all (Program-supporting) activities* at schools during visits of the mobile clinic. Let the number of half-hour increments observed for individual i at school s, while the mobile clinic is located at school s, be H1[i,s]. This time is to be divided among regimens on the basis of clinical participation rates by regimen at school s (discussed in B.1. above) and average treatment times by regimen.† Specifically, the amount of H1[i,s] to be allocated to regimen r is to be called H1[i,s,r] and is given by:

$$H1[i,s,r] = \frac{N1[s,r] \cdot I[r]}{\sum_r \left\{ N1[s,r] \cdot I[r] \right\}} \cdot H1[i,s] \qquad (4)$$

where I[r] is the average treatment time for regimen r. The sum of H1[i,s,r] over all schools is the time spent by i in support of the clinic component of regimen r. Call this H1[i,r]:

$$H1[i,r] = \sum_s H1[i,s,r] \qquad (5)$$

Classroom Activities. The "Classroom" group consists of all activities at schools other than during visits of the mobile clinic. Let the number of such half-hour increments for individual i and school s be H2[i,s]. This time is to be divided among regimens according to their respective classroom participation rates at school s. That is, H2[i,s,r]--regimen r's share of H2[i,s]--is given by:

$$H2[i,s,r] = \frac{N2[s,r]}{\sum_r N2[s,r]} \cdot H2[i,s] \qquad (6)$$

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*In the interest of brevity, no further mention of the operational/non-operational distinction will be made. It should be understood, therefore, that "activities" will henceforth mean "activities in support of Program operations" and that staff time and cost totals have already been reduced to account for "non-operational" activities.

†The computation of average treatment times is not shown, because to do so would greatly complicate the nomenclature. Briefly, average treatment time for regimen i is total clinic personnel time at schools with only regimen-i students (or for days when only regimen-i students are served) divided by the number of regimen-i students at those schools (or treated on those days).

The sum of H2[i,s,r] over all schools is the time spent by i in support of the classroom component of regimen r. Call this H2[i,r]:

$$H2[i,r] = \sum_{s} H2[i,s,r] \qquad (7)$$

Overhead Activities. The "Overhead" group includes all activities performed at locations other than participating schools. This time, to be called H3[i] in the case of individual i, cannot be directly allocated to regimens. Instead, it is converted to a cost immediately below, to be combined with other overhead costs and arbitrarily divided among regimens in B.6.

Allocation of Labor Costs. Salary, fringe benefit, travel cost reimbursement, and other miscellaneous Program expenditures for each member of the site staff are reported monthly in the *Site Staff Expenditure Summary*. As in the case of activity codes, the details of each site's labor costs may prove useful in explaining why one site's costs of care were higher or lower than another's. But for present purposes, all that matters is the total of all expenditures for individual i for the year as a whole. Let this total be represented by L[i].

The portion of i's total cost to be allocated to regimen r is called L[i,r] and depends on clinical and classroom time spent by i in support of regimen r divided by i's total time H[i]:

$$L[i,r] = \frac{H1[i,r] + H2[i,r]}{H[i]} \cdot L[i] \qquad (8)$$

The portion of i's total cost to be allocated to overhead is similarly defined and will be called L[i,∅]:

$$L[i,\emptyset] = \frac{H3[i]}{H[i]} \cdot L[i] \qquad (9)$$

The sum of the L[i,r] over all individuals is the direct labor cost of regimen r, L[r]:

$$L[r] = \sum_{i} L[i,r] \qquad (10)$$

The sum of the L[i,∅] over all individuals is the total overhead labor cost, L[∅]:

$$L[\emptyset] = \sum_i L[i,\emptyset] \qquad (11)$$

B.3. Supplies Costs

The total cost of supplies of type f is the value of starting inventory plus purchases made during the year, less the value of the year-end inventory. Let this total cost for supplies of type f be S[f].

Some of these supplies (e.g., plastic sealants and fluoride mouthrinse) are used in only one procedure,* while others are used in two or more different procedures. In order to represent these usage relationships, define a set of variables u[f,g] as follows:

u[f,g] = 1 if supplies of type f are used in procedure g

u[f,g] = 0 if supplies of type f are not used in procedure g.

The linkage between procedures and regimens may similarly be defined by a set of variables v[g,r], defined as

v[g,r] = 1 if procedure g is used in regimen r

v[g,r] = 0 if procedure g is not used in regimen r.

Then each regimen's usage of supplies of type f, designated w[f,r], may be represented by

$$w[f,r] = \sum_g u[f,g]v[g,r] \qquad (12)$$

The products u[f,g]v[g,r] will be equal to one if supply f is used in procedure g, and procedure g is used in regimen r. They will be zero if supply f is not used in procedure g, or if procedure g is not used in regimen r, or if both of these are true. The sum of the u[f,g]v[g,r]--that is, the w[f,r]--can be zero, one, or more.

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*Clinical and classroom *procedures* are the constituent elements of the Program's *regimens* of care. See Table A-3, p. 46.

The total cost for supplies of type f, S[f], is to be allocated among regimens according to their usage-weighted participation rates. That is, regimen r's share of f's cost is

$$S[f,r] = \frac{W[f,r] \cdot N1[r]}{\sum_{r=1}^{3} W[f,r] \cdot N1[r] + \sum_{r=4}^{5} W[f,r] \cdot N2[r]} \cdot S[f] \qquad (13)$$

for regimens one, two, or three; for regimen four or five, it is

$$S[f,r] = \frac{W[f,r] \cdot N2[r]}{\sum_{r=1}^{3} W[f,r] \cdot N1[r] + \sum_{r=4}^{5} W[f,r] \cdot N2[r]} \cdot S[f] \qquad (14)$$

The reason for two formulas is that regimen participation rates are defined by clinical participation (N1[r]) for regimens involving the clinic (i.e., r = 1,2,3) and by classroom participation (N2[r]) for classroom-only regimens (i.e., r = 4,5). The total cost of supplies for regimen r, S[r], is found by summing the S[f,r] over all types of supplies:

$$S[r] = \sum_{f} S[f,r] \qquad (15)$$

B.4. Capital Costs

Clinical equipment of type j has a purchase price as of Program initiation PØ[j], an estimated useful life of t[j] years, and a scrap value of Pt[j] at the end of its useful life. The difference between PØ[j] and Pt[j] is the total depreciation expense for type j equipment. If it is assumed that depreciation is constant over the life of the equipment, the annual depreciation expense, D[j], is given by

$$D[j] = \frac{PØ[j] - Pt[j]}{t[j]} \qquad (16)$$

During the first year of Program operations, then, capital costs arising from equipment of type j consist of depreciation expense D[j],

repair costs X[j], and interest foregone on the PØ[j] dollars tied up in the equipment. If z is the relevant interest rate, first-year type j capital costs may be written

$$K[j] = D[j] + X[j] + z \cdot P\emptyset[j] \tag{17}$$

During the second year of Program operations, type j equipment has the same depreciation expense D[j], possibly different repair costs X'[j], and foregone-interest expense on its *depreciated* value. That is, there are no longer PØ[j] dollars tied up in type j equipment, because D[j] dollars have been lost to depreciation; interest is foregone only on its remaining value, PØ[j] - D[j]. Second-year type j capital costs may therefore be written

$$K'[j] = D[j] + X'[j] + z \cdot \left[P\emptyset[j] - D[j]\right] \tag{18}$$

By similar reasoning, third-year type j capital costs are

$$K''[j] = D[j] + X''[j] + z \cdot \left[P\emptyset[j] - 2D[j]\right] \tag{19}$$

and so on. Total capital costs for the year* are found by summing K[j] over all types of equipment:

$$K = \sum_{j} K[j] \tag{20}$$

Total capital costs are to be allocated among the three regimens employing clinical procedures on the basis of the regimens' relative contributions to total man-hours of clinic operation. Recalling from expression (5) that Hl[i,r] is the amount of time spent by individual i in regimen r's clinical activities, Hl[r] is now defined to be regimen r's total clinical man-hours:

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*Only the algebra for the first year is shown; results for other years differ only by substitution of K'[j], K"[j], or K"'[j] for K[j].

$$Hl[r] = \sum_{i} Hl[i,r] \qquad (21)$$

Regimen r's share of capital costs, to be called K[r], is therefore:

$$K[r] = \frac{Hl[r]}{\sum_{r=1}^{3} Hl[r]} \cdot K \qquad (22)$$

B.5. Direct Costs

The direct costs of regimens one, two, and three are simply the sums of labor costs, supplies costs, and capital charges allocated to them:

$$DC[r] = L[r] + S[r] + K[r] \qquad r = 1,2,3 \qquad (23)$$

Regimens four and five have direct labor and supplies costs, but no capital charges:

$$DC[r] = L[r] + S[r] \qquad r = 4,5 \qquad (24)$$

B.6. Overhead Costs

Overhead costs consist of unallocated labor costs L[Ø] and the sum of non-treatment expenditures M:

$$OC = L[Ø] + M \qquad (25)$$

The two methods by which overhead costs are to be indirectly linked to regimens--i.e., per capita and pro rata--are discussed in turn below.

Per Capita Allocation of Overhead. For reasons given in the text, regimen six (the longitudinal control group) is to be included in the per capita allocation of overhead costs. This requires a measure of participation for regimen six, and since the annual examination is the only point of Program contact for regimen six children, the participation measure must be the number of such children examined. In order

to distinguish this measure from clinical participation (N1[r]) and classroom participation (N2[r]), it will be labelled N3(6).*

Each regimen's share of overhead costs, under per capita allocation, is its participation rate divided by total participation:

$$OC1[r] = \frac{N1[r]}{\sum_{r=1}^{3} N1[r] + \sum_{r=4}^{5} N2[r] + N3[6]} \cdot OC \quad r=1,2,3 \qquad (26)$$

$$OC1[r] = \frac{N2[r]}{\sum_{r=1}^{3} N1[r] + \sum_{r=4}^{5} N2[r] + N3[6]} \cdot OC \quad r=4,5 \qquad (27)$$

$$OC1[6] = \frac{N3[6]}{\sum_{r=1}^{3} N1[r] + \sum_{r=4}^{5} N2[r] + N3[6]} \cdot OC \qquad (28)$$

Pro Rata Allocation of Overhead. Pro rata allocation means that each regimen bears a share of overhead costs equal to its share of total direct costs:†

$$OC2[r] = \frac{DC[r]}{\sum_{r} DC[r]} \cdot OC \qquad (29)$$

B.7. Total Costs

The total cost of each regimen is the sum of its direct and overhead costs. Because there are two methods planned for allocating overhead, there are two versions of total costs:

$$TC1[r] = DC[r] + OC1[r] \qquad (30)$$

$$TC2[r] = DC[r] + OC2[r] \qquad (31)$$

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*The number of examinations performed can and will also be used as a measure of participation for regimens one through five. But in those cases the purpose of N3[r] is testing the plausibility of N1[r] and N2[r].

†Note that since regimen six has no direct costs, it bears no share of pro rata-allocated overhead.

B.8 Costs Per Child

The cost per child in each regimen is the regimen's total cost divided by the regimen's participation rate. For regimens one, two, and three, the relevant participation rate is clinical (N1[r]); for regimens four and five, the classroom participation rate (N2[r]) is used; and for regimen six--which has a non-zero cost only under per capita overhead allocation--the number of examinations (N3[6]) defines participation:

$$\left.\begin{aligned} TCP1[r] &= \frac{TC1[r]}{N1[r]} \\ TCP2[r] &= \frac{TC2[r]}{N1[r]} \end{aligned}\right\} \quad r = 1,2,3 \qquad (32), (33)$$

$$\left.\begin{aligned} TCP1[r] &= \frac{TC1[r]}{N2[r]} \\ TCP2[r] &= \frac{TC2[r]}{N2[r]} \end{aligned}\right\} \quad r = 4,5 \qquad (34), (35)$$

$$TCP1[6] = \frac{TC1[6]}{N3[6]} \qquad (36)$$